

AN EVALUATION OF TWO SHELL EGG MARKETING SYSTEMS

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PREFACE AND ACKNOWLEDGMENTS

This report is part of a continuing research program of the Agricultural Research Service designed to find more efficient and less costly methods of handling, packaging, and transporting agricultural products from producer to consumer.

Grateful appreciation is extended to the owners and managers of the shell egg packing plants, central distribution warehouses, and retail stores who cooperated in this study.

Appreciation is also extended to Robert C. Mongelli, industry economist, Market Operations Research Laboratory, Agricultural Marketing Research Institute, for assistance in collecting data and in preparing the final draft of this report, and to Jesse W. Goble, agricultural marketing specialist, Animal Products Marketing Laboratory of this Institute, for his assistance during the initial phases of the study.

This study was conducted under the general supervision of John C. Bouma, Chief, Market Operations Research Laboratory.

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AN EVALUATION OF TWO SHELL EGG MARKETING SYSTEMS

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SUMMARY

The purpose of this study was to identify and to determine the costs of two systems of handling, packaging, and transporting shell eggs from the end of the packing line to the display counter in retail stores. The first system was direct-store delivery from packing plant to retail store, and the second was warehouse-to-store delivery from packing plant, to and through central distribution warehouse, and to retail store. Various combinations of handling equipment and master cases were examined within each of these two systems.

This study was conducted in three large egg packing plants, three food distribution warehouses, and nine retail stores or supermarkets.

At the packing plant, costs for both systems were identical. Total labor, equipment, and master case costs to move shell eggs from the end of the packing line, to and through refrigerated storage, and to the delivery truck ranged from \$0.28 per 100 dozen eggs or \$3.59 per ton using an electric pallet transporter with a 30-dozen, 200-pound bursting strength, collapsible case to \$0.92 per 100 dozen eggs or \$11.72 per ton using a manual pallet transporter with a 30-dozen, 200-pound bursting strength, noncollapsible case.

Distribution costs varied between systems. Costs for direct-store distribution from plant to retail store amounted to \$1.71 per 100 dozen eggs or \$21.89 per ton. Costs for warehouse-to-store distribution from packing plant, to and through central warehouse, and to retail store ranged from \$1.85 per 100 dozen or \$23.53 per ton to \$1.88 per 100 dozen or \$23.98 per ton depending on case capacity.

Costs at the retail store varied considerably. They ranged from \$0.75 per 100 dozen or \$9.63 per ton to \$1.35 per 100 dozen or \$17.31 per ton depending on type of handling equipment and master case capacity.

The total costs to handle and to distribute shell eggs from the packing plant to the display counter at the retail store using the most efficient handling methods and cases studied amounted to \$2.99 per 100 dozen or \$38.67 per ton with the direct-store system and \$2.88 per 100 dozen or \$36.74 per ton with the warehouse-to-store system.

Based on the parameters in this study, the warehouse-to-store delivery system was \$0.11 per 100 dozen or \$1.93 per ton less costly than the direct-store system. These costs reflect a savings of \$29 per truckload. However, because of the constant distance factor between packing plant and retail store that has been used in this report, the stated costs should not be assumed to remain constant. They will vary with the transport distance.

The most noteworthy findings of this study indicate the potential savings the egg industry might realize by incorporating the most efficient master case into its operations. This study shows that of the three types of cases examined, the 30-dozen, 200-pound bursting strength, collapsible case is the most efficient and the least costly for handling and transporting shell eggs. Its use would result in a savings of up to \$7.93 per ton or \$119 per truckload.

INTRODUCTION

Background

Traditionally, considerable attention has been directed toward identifying and minimizing costs associated with the production and processing of shell eggs, whereas the handling and transporting of these eggs from the end of the packing line to the retail outlet have not been given as much attention. Because of rapidly rising costs of labor and equipment, more emphasis is now being directed toward the distribution of shell eggs. The effectiveness of distribution includes being able to recognize and understand alternative systems and sub-systems of distribution.

Research investigations of the distribution segment of the marketing channel from packing plant to retail store generally have been directed toward smaller firms. Studies of packing operation costs have frequently included distribution costs as part of the analysis. Few studies have been designed to specifically investigate the distribution system itself.

Two studies¹ reported since 1970 analyze two alternative systems of distributing shell eggs: (1) Direct-store delivery—from packing plant to retail outlet and (2) warehouse-to-store delivery—from packing plant, to and through a central warehouse, and to retail outlet. Emphasis in these studies was on the distance between the packer and the retail outlets.

Purpose and Procedures

The purpose of this study was to identify and determine the costs of these two systems of distributing shell eggs from the end of the packing line to the display counter in retail stores. The emphasis in this report, however, is not on distance but on alternative types of handling equipment and master cases.

¹ Jackson, Geoffrey H., and Forker, Olan D. An Analysis of Factors Influencing Shell Egg Distribution Costs. Cornell Univ. Dept. Agr. Econ. AE Res. 318, 38 pp. 1970.

Vertrees, James G., and Larzelere, Henry E. Factors Affecting Shell Egg Distribution Channel Costs. Mich. State Univ. Depart. Agr. Econ. AE Rpt. 214, 50 pp. 1972.

The direct-store and warehouse-to-store marketing systems are discussed here under Packing Plant, Distribution, and Retail Store.

In the packing plant section, the costs of handling shell eggs from the end of the packing line, to and through refrigerated storage, and onto the delivery truck are evaluated. Two kinds of handling equipment and three types of master cases are examined.

In the distribution section, the costs differ for each of the marketing systems. For the direct-store system, the distribution costs include trucking the shell eggs by tractor-trailer from the packing plant to the retail outlets. For the warehouse-to-store system, these costs include trucking the shell eggs by tractor-trailer from the packing plant to a central distribution warehouse, unloading and storing, assembling, loading onto delivery trucks, and delivering to retail outlets by tractor-trailer. One type of handling equipment and two sizes of master cases are considered.

In the retail store section, the costs are analyzed of unloading shell eggs to cooler storage and then moving them to display shelves. Four types of handling equipment and two sizes of master cases are evaluated.

This report concludes with a comparison of the two delivery systems. The costs in this comparison reflect only those of the most efficient equipment studied for each of the three types of master cases within each system.

Most of the information was obtained by detailed time studies at each of the facilities studied and was implemented by personal interviews with managers, truckers, employees, equipment and box manufacturers, Federal and State government officials, and others involved with the marketing of shell eggs. A more detailed explanation of research techniques, time study procedures, and cost derivations may be found in the appendix.

Scope of Study

This study was conducted in three large egg packing plants in Virginia, Maryland, and Pennsylvania, three food distribution ware-

houses in the Washington, D.C., metropolitan area, and nine retail stores or supermarkets that receive from the three warehouses.

Because two different size master cases have been evaluated in this report, it would be misleading to determine unit costs on a "per case" basis. Therefore all costs have been expressed on the basis of "per 100 dozen" eggs. To further

simplify expression of unit costs and to give a different perspective, costs have also been determined on a "per ton" basis.²

Excluded from this study were the costs and designs of egg cartons.

The field work for this report was conducted during late 1973 and early 1974. All costs are current as of January 1974.

RESULTS

Packing Plant

The three shell egg packing plants studied all handled over 5,000 cases weekly and made direct-store and warehouse-to-store deliveries. In addition, they were all approximately the same distance from the Washington, D.C., metropolitan area, used similar types of handling equipment, and delivered at least part of their volume by tractor-trailer.

Working conditions at these plants were also similar. Lighting was adequate, floors were smooth and kept free of obstruction, aisle and door widths were sufficient, equipment was in satisfactory working order, and the supply of work was relatively continuous.

Because the activities at these plants were virtually identical for the direct-store and warehouse-to-store delivery systems, the following discussion applies to both.

Two typical kinds of handling equipment (fig. 1) were observed within the packing plant. The first incorporated a hydraulic manual pallet transporter with 2,000-pound capacity and the second a 12-volt electric pallet transporter with 4,000-pound capacity. Both types of equipment used conventional two-way, 48- by 36-inch pallets.

Three types of master cases with two different capacities (fig. 2) were evaluated for each delivery system. The first was a 24-dozen carton capacity, 275-pound bursting strength, collapsible case with a built-in short Z liner. The second was a 30-dozen carton capacity, 200-pound bursting strength, noncollapsible case with a split T or short Z liner. The third was a 30-dozen capacity, 200-pound bursting strength, collapsible case with a built-in short Z liner.

Information on handling includes those activities occurring from the time egg cartons were packed in cases at the end of the packing line until they were placed unpalletized in the delivery truck or tractor-trailer.

Labor consisted of four major functions: Load from case packing station onto pallets, move to refrigerated storage, move from refrigerated storage to delivery trailer, and hand-stack in trailer.

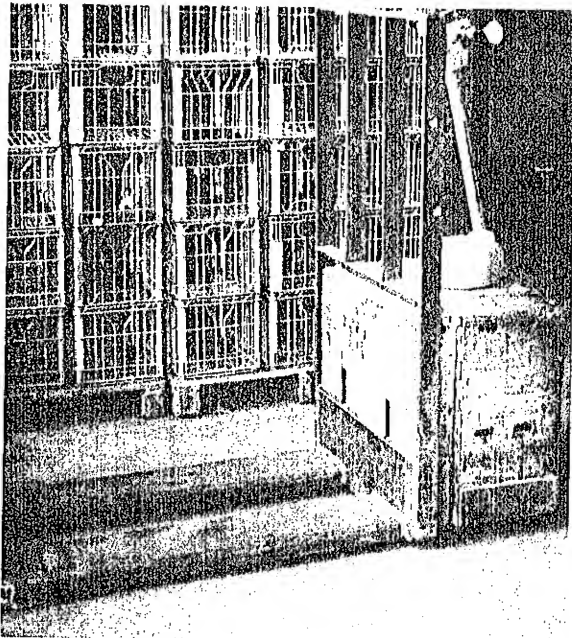
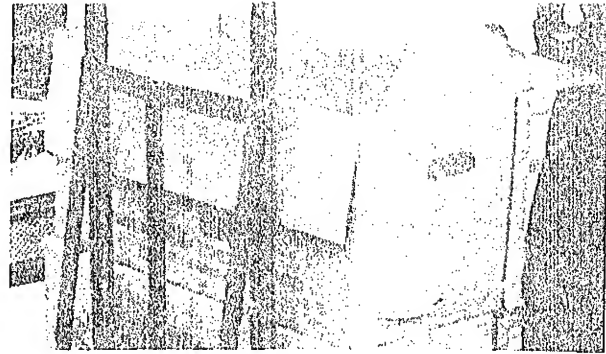
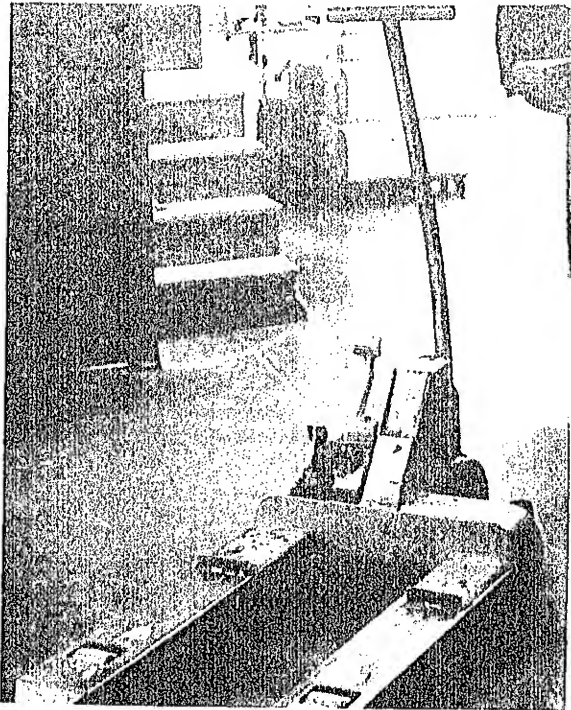
Normally each of these functions would be broken down into elements and time studied individually. However, because of the various and erratic methods used by different handlers to perform these tasks, it would be difficult and misleading to do so. Therefore each of these four functions has been treated as an element. For purposes of this report, all activities occurring between the end of the packing line and storage in the delivery truck are together considered a single handling function.

Labor Costs

Table 1 shows the labor time and cost to move shell eggs from the end of the packing line, through refrigerated storage, to hand-stacked in delivery truck using two case sizes and two types of equipment.

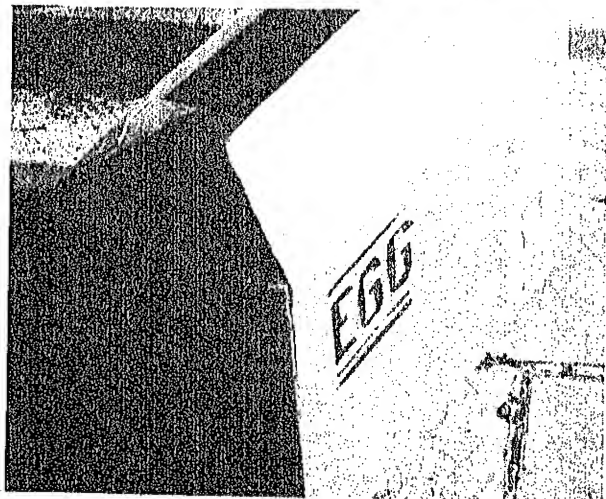
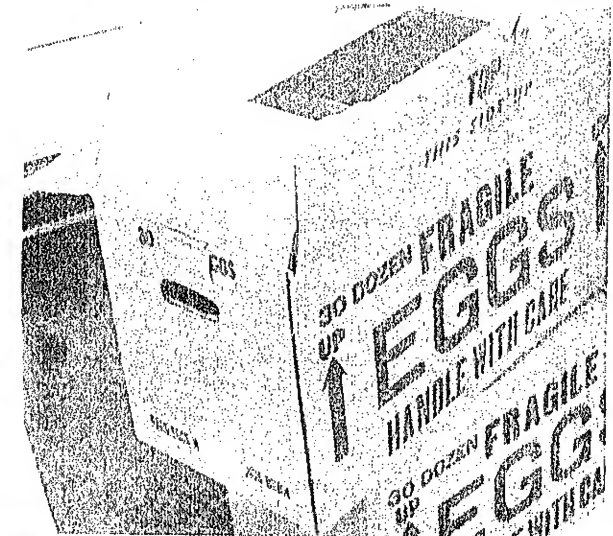
Palletizing cases at the case packing station was typically performed in one of two ways. The first consisted of the packers carrying full cases by hand and placing them on nearby pallets. The second consisted of packers pushing full cases along the conveyor to a dead end, where they were lifted off by handlers and placed on nearby pallets.

² 1 ton of eggs equals 42.55 thirty-dozen cases or 55.33 twenty-four-dozen master cases.



PN-3947, PN-3948

Figure 1.—Two types of handling equipment at shell egg packing plants: *Above*, hydraulic manual pallet transporter; *below*, electric pallet transporter.



PN-3949, PN-3950, PN-3951

Figure 2.—Shell egg packing cases (*top to bottom*): 24-dozen, 275-pound bursting strength, collapsible case with built-in short Z liner; 30-dozen, 200-pound bursting strength, noncollapsible case with short Z or split T liner; 30-dozen, 200-pound bursting strength, collapsible case with built-in short Z liner.

TABLE 1.—*Labor time and cost to move shell eggs from end of packing line, through refrigerated storage, to handstacked in delivery truck using 2 case sizes and 2 types of equipment*¹

Case size and labor element	Manual pallet transporter				Electric pallet transporter			
	Time per—		Cost per—		Time per—		Cost per—	
	100 doz	Ton	100 doz	Ton	100 doz	Ton	100 doz	Ton
	<i>Man-min</i>	<i>Man-min</i>			<i>Man-min</i>	<i>Man-min</i>		
<i>24 doz</i>								
Load from case packing station onto pallets.....	0.678	8.640	\$0.045	\$0.576	0.678	8.640	\$0.045	\$0.576
Move to refrigerated storage....	.198	2.562	.013	.171	.150	1.920	.010	.128
Move from refrigerated storage to truck.....	.198	2.562	.013	.171	.150	1.920	.010	.128
Handstack in truck.....	1.074	13.758	.072	.917	.678	8.640	.045	.576
Total.....	2.148	27.522	.148	1.835	1.656	21.120	.110	1.408
<i>30 doz</i>								
Load from case packing station onto pallets.....	.540	6.894	.036	.460	.540	6.894	.036	.460
Move to refrigerated storage....	.162	2.040	.011	.136	.120	1.530	.008	.102
Move from refrigerated storage to truck.....	.162	2.040	.011	.136	.120	1.530	.008	.102
Handstack in truck.....	.858	10.980	.057	.732	.540	6.894	.036	.460
Total.....	1.722	21.954	.115	1.464	1.320	16.848	.088	1.124

¹ Based on average 260-ft round trip and 30 cases per pallet. For details pertaining to labor rates, see appendix.

Moving to refrigerated storage consisted of traveling with an empty pallet transporter, picking up a full load, traveling to refrigerated storage (fig. 3), and positioning and releasing the load. Depending on the situation and the individual involved, the handler would often have to stop to open or close the cooler door. This problem could be corrected by installing double-acting swinging doors and a permanent sliding door.

Movement from refrigerated storage to delivery trailer consisted of traveling empty with a transporter, picking up a full load, traveling loaded to the inside of the trailer with an electric pallet transporter or to the tailgate of the trailer with a manual pallet transporter, and stacking cases individually in the trailer from the respective pallets. In most instances the handler was unable to maneuver a full pallet load over the dock plate and into the trailer using a manual pallet transporter. Therefore for this piece of equipment, the labor time and

cost allocated for handstacking in the trailer were based on hand-carrying cases from the tailgate area to storage in the trailer. With the electric pallet transporter, the time and cost were based on handstacking from pallets positioned within the trailer.

As shown in table 1, total labor costs for moving shell eggs from the end of the packing line to storage in the delivery trailer ranged from a low of \$0.088 per 100 dozen or \$1.12 per ton using an electric pallet transporter and a 30-dozen case to a high of \$0.143 per 100 dozen or \$1.84 per ton using a manual pallet transporter and a 24-dozen case.

Handling Equipment Costs

The manual pallet transporter uses standard pallets and is a particularly good choice if one anticipates further increases in volume and the need to adopt motorized equipment later. It has the lowest initial cost of any standard pallet system.

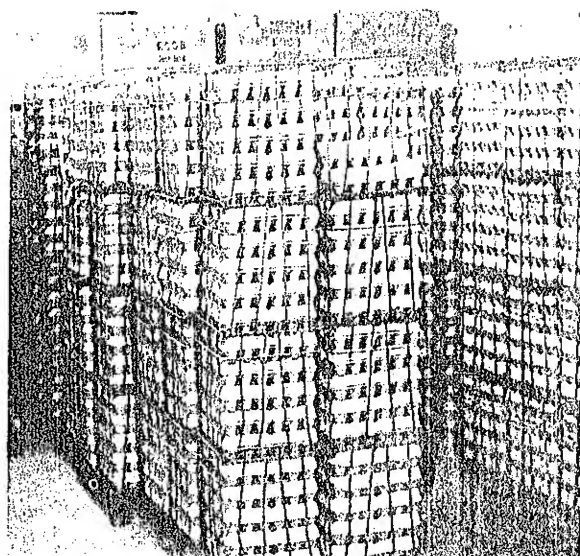


Figure 3.—Refrigerated storage in a shell egg packing plant.

The electric pallet transporter has two important advantages at the packing plant: (1) A handler can work more efficiently alone, since he can move pallet loads across dock plates and thus reduce idle time for expensive delivery trucks. (2) When using the electric transporter, a handler who has less physical strength and stamina can move larger volumes without excessive fatigue.

Table 2 shows the handling equipment costs to move shell eggs from the end of the packing

line, through refrigerated storage, to hand-stacked in delivery truck. Transporter costs were based on ownership costs per hour (see appendix) times the man-hours required for the job. Pallet costs were based on annual ownership costs per pallet divided by the annual volume handled per pallet. An annual turnover rate per pallet of 156 was used. With 30 cases to a pallet, this amounted to 4,680 cases per year per pallet.

Equipment costs ranged from a low of \$.004 per 100 dozen or \$.05 per ton using a manual pallet transporter and a 30-dozen case to a high of \$.013 per 100 dozen or \$.157 per ton using an electric pallet transporter and a 24-dozen case.

Master Case Costs

Because two of the three master cases studied were paid for by the packing plant, the total cost of all cases was allocated to the packing plant. The total costs for the three types of master cases and liners considered in this study were as follows:

Type of case	Cost ¹ per—	
	100 doz	Ton
24-do, 275-lb bursting strength, collapsible	\$0.246	\$ 3.15
30-do, 200-lb bursting strength:		
Noncollapsible .....	.800	10.21
Collapsible .....	.183	2.34

¹ For detailed information, see appendix table 17.

TABLE 2.—Handling equipment costs to move shell eggs from end of packing line, through refrigerated storage, to handstacked in delivery truck using 2 case sizes and 2 types of equipment ¹

Type of equipment	24-do, case per—		30-do, case per—	
	100 doz	Ton	100 doz	Ton
Manual pallet transporter.....	\$0.002	\$0.028	\$0.002	\$0.022
Pallets (48 by 36 inches).....	.003	.035	.002	.028
Total.....	.005	.063	.004	.050
Electric pallet transporter.....	.010	.122	.008	.097
Pallets (48 by 36 inches).....	.003	.035	.002	.028
Total.....	.013	.157	.010	.125

¹ For detailed information, see appendix table 16.

Costs ranged from a low of \$0.183 per 100 dozen or \$2.34 per ton for the 30-dozen, 200-pound bursting strength, collapsible case to \$0.800 per 100-dozen or \$10.21 per ton for the 30-dozen, 200-pound bursting strength, non-collapsible case.

The large difference in costs between cases was a result of the number of uses the collapsible and reusable cases had as compared with the noncollapsible and generally nonreusable cases.

Total Costs

Table 3 shows the total labor, handling equipment, and case costs for moving shell eggs from the end of the packing line, through refrigerated storage, to handstacked in the delivery truck. The cost of the master cases reflects their respective cost not only at the packing plant but for the entire marketing channel through which they are moved.

Total costs ranged from \$0.28 per 100 dozen or \$3.59 per ton using an electric pallet transporter with a 30-dozen, 200-pound bursting strength, collapsible case to \$0.92 per 100 dozen or \$11.72 per ton using a manual pallet transporter and a 30-dozen, 200-pound bursting strength, noncollapsible case.

Distribution

In this section are described the two delivery systems and their costs for distributing shell

eggs from the packing plant to the retail store. As a result of uncontrollable variables, it was not possible to delineate the trucking costs accurately by size of case used. Therefore all trucking cost figures are based on average tonnage delivered and not on the number of cases of each size transported within the truck.

All transportation vehicles studied were 38- and 40-foot refrigerated tractor-trailers (fig. 4).

Because distribution costs for the direct-store system are based partly on costs found for the warehouse-to-store system, the latter is discussed first.

Warehouse-to-Store System Costs

The operations within this distribution system were from plant to warehouse, through warehouse, and from warehouse to retail store.

From Plant to Warehouse.—This operation included the delivery of shell eggs from the packing plant to a central distribution warehouse. The average trailer load was approximately 15 tons and the average round trip between plant and warehouse was slightly under 300 miles.

Table 4 shows the costs and their derivation for transporting shell eggs from plant to warehouse. These costs averaged \$0.71 per 100 dozen or \$9.07 per ton for the three packing plants studied. Costs were determined by dividing

TABLE 3.—*Total labor, handling equipment, and case costs to move shell eggs from end of packing line, through refrigerated storage, to handstacked in delivery truck using 3 types of cases, 2 case sizes, and 2 types of equipment*¹

Type of case	Manual pallet transporter cost per—		Electric pallet transporter cost per—	
	100 doz	Ton	100 doz	Ton
24-dozen, 275-lb bursting strength, collapsible.....	\$0.394	\$5.048	\$0.369	\$4.715
30-dozen, 200-lb bursting strength:				
Noncollapsible.....	.919	11.724	.898	11.459
Collapsible.....	.802	9.854	.281	3.589

¹ Based on tables 1, 2, and p. 6 data.

[illegible]

Plant C:															
Tractor (diesel)															
38-foot refrigerated trailer	9,263	2	100,000	45,760	18,526	.40	1,373	5.75	7,895	26,421	.58	46,800	3,656.3	.57	7.23
Total or average	-----			123,500	42,691	.35	3,531	5.75	20,304	62,995	.51	88,920	6,946.9	.71	9.07

Information supplied by owners or managers of packing plant.

² Equals initial cost of vehicles less salvage value divided by years depreciated.

Insurance includes liability of \$50,000–\$100,000, \$25,000 property damage, and nondeductible comprehensive. It is assumed driver has a good driving record.

* Assuming \$0.60 per quart of oil and \$0.45 per gallon of gas with 4.5 mi per gallon.

Equals total annual ownership and operating cost per vehicle multiplied by quotient of (actual miles driven annually to deliver to central distribution

Equals total annual ownership and operating cost per warehouse divided by total miles truck is driven per year).

⁵ Assumes average of 50 mi/h over road plus delay and unloading time at warehouse.

Based on typical straight time rate of \$4.60 per hour plus 25 percent for fringe benefits equals \$5.75.

³ Based on 25 oz per dozen, 37.5 lb per 24-dozen case, 47 lb per 30-dozen case (U.S. Dept. Agr. Econ. Res. Serv. Statist. Bul. 362, "Conversion Factors and

Weights and Measures for Agricultural Commodities and Their Products").

Through Warehouse.—All three warehouses studied were operated by corporate chains. They all had single level facilities with truck-bed height docks for unloading and loading operations. They were near each other and served the same geographical area.

Handling methods were basically the same at all warehouses with variations mainly in the techniques used by individual handlers, the distance between one area of the warehouse and another, and the capacity of the storage areas.

The principal handling system used at all warehouses incorporated a 12-volt electric pallet transporter with 4,000-pound capacity. Used in conjunction with this equipment were conventional two-way, 48- by 40-inch hardwood pallets. One of the warehouses used 24-dozen master cases and the other two used 30-dozen cases.

Handling information included those activities occurring from the time incoming vehicles backed up to the dock in preparation for unloading to the time outgoing vehicles were loaded and ready to deliver. Specifically labor consisted of three basic functions: Unloading shell eggs and moving them to storage, assembling, and loading on delivery vehicles.

Transportation distances for each function varied considerably between warehouses. Since this would introduce variations in time requirements for the distance traveled, all data have been adjusted to reflect a round trip of 150 feet for each function.

All warehouses studied generally used unloaders who were hired by the incoming truck driver. These handlers were paid \$25 to \$30 per trailer load at an average cost per case of eggs of \$0.03 to \$0.035 or about \$1.75 per ton. To arrive at an unloading cost that would be applied to other typical warehouses, time studies were made of the unloading operation and an allocation of present warehouse wage rates was used. All incoming trailers contained

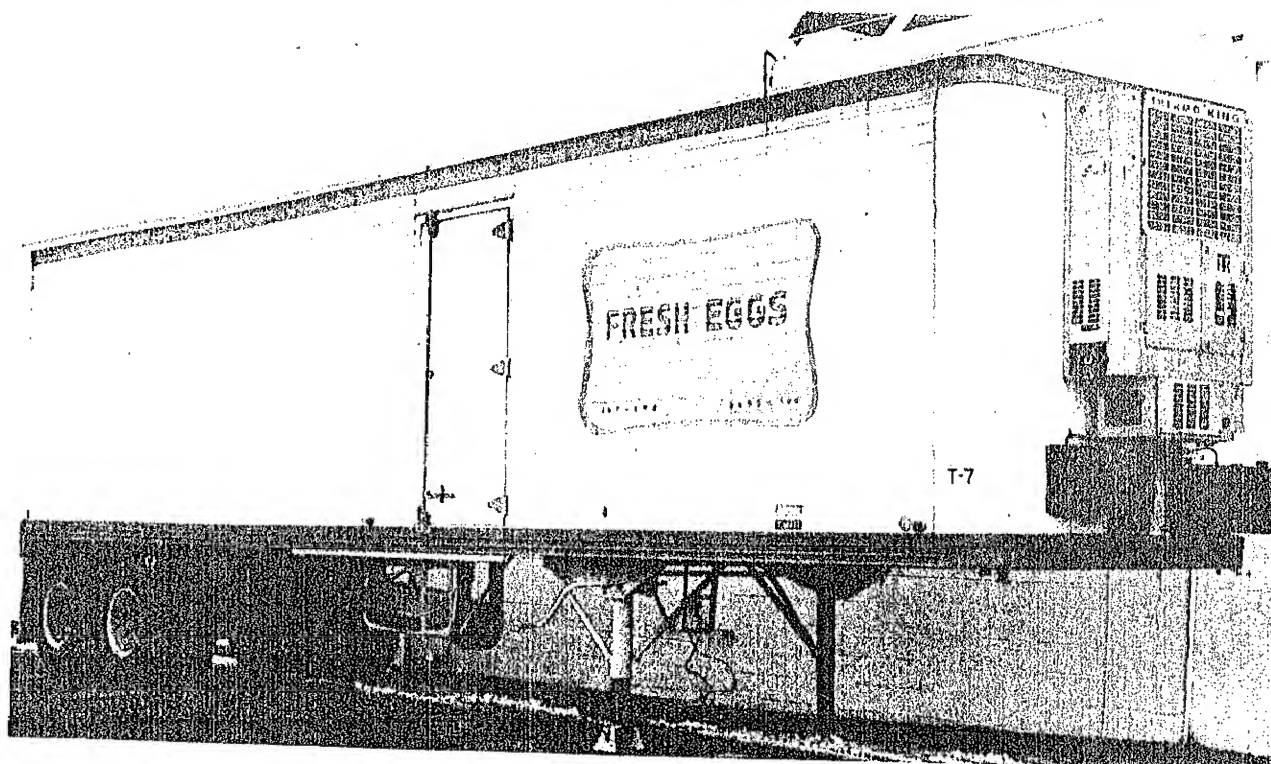


Figure 4.—A 33-foot refrigerated trailer.

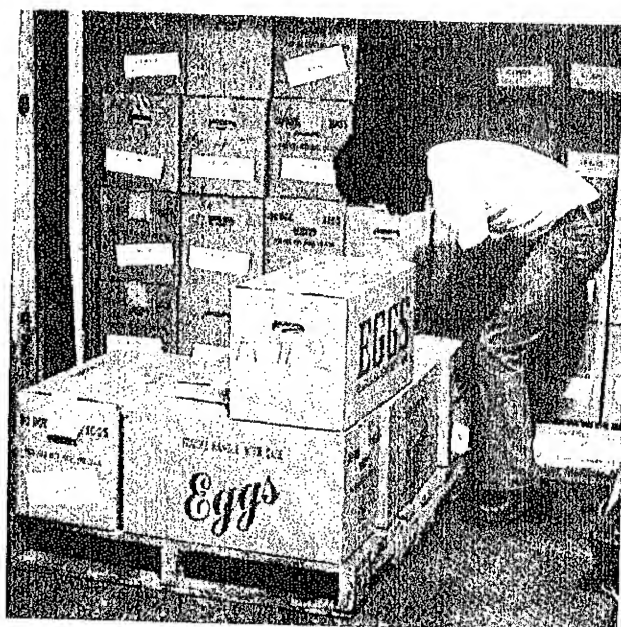
PN-2053

an average shell egg load of approximately 15 tons.

The unloading function consisted of four principal elements:

- *Set up and clean up.*—Set up includes opening trailer doors, positioning bridge plate or adjusting dock leveler, and removing bracing from load. Clean up includes closing trailer doors and cleaning up the immediate area.
- *Position pallet.*—Pallet is lifted by hand from a stack near the rear of the trailer and placed inside the trailer. This element also includes replenishing the stack of pallets when needed.
- *Stack cases on pallet.*—Cases are placed on pallets six to a layer (fig. 5). Two of the warehouses stacked cases 5 high for a total of 30 cases to a pallet. The third warehouse that used the 30-dozen case stacked 4 high with a single case placed on top for a total of 25 cases to a pallet.
- *Transport to storage and return.*—Handler picks up pallet inside truck with pallet transporter, moves load to storage area of ware-

house, and returns empty to inside of trailer for another pallet.



PN-3064

Figure 5.—Unloading egg cases from truck and placing six to a layer on pallet.

Table 5 shows labor time and cost for unloading shell eggs at the distribution warehouse by electric pallet transporter using two sizes of cases and pallet loads.

The assembly function brought together in a central area all shell eggs that were to be delivered to stores. This function varied somewhat between warehouses, and therefore elements that were not considered typical were excluded. Because of the overlap of several elements that were time studied and the varying order in which they were performed, the total assembly function has been described as one element. This element includes obtaining empty pallets, assembling cases of eggs on empty or partially loaded pallets (fig. 6), identifying the unit load with crayon, securing load with cord

(fig. 7), and moving from storage to assembly area. The labor time and cost to assemble shell eggs by electric pallet transporter using two case sizes were as follows:

Case size	Time (man-min) per—		Cost per—	
	100 doz	Ton	100 doz	Ton
24 doz	0.504	6.516	\$0.058	\$0.749
30 doz	.402	5.196	.046	.598

These data were based on an average 150-foot round trip and 25 cases per pallet.

Loading delivery vehicles included moving loaded pallets from the assembly area into the trailer. This function was divided into three elements:

• *Set up and clean up.*—Set up includes positioning bridge plate or adjusting dock leveler.

TABLE 5.—Labor time and cost to unload shell eggs at warehouse with electric pallet transporter using 2 case sizes and pallet loads ¹

Case size, pallet load, and labor element	Time per—		Cost per—	
	100 doz	Ton	100 doz	Ton
	Man-min	Man-min		
<i>24 doz</i>				
30 cases per pallet:				
Set up and clean up.....	0.018	0.216	\$0.002	\$0.025
Position pallet.....	.078	.960	.009	.110
Stack cases on pallet.....	.426	5.448	.049	.627
Transport to storage and return.....	.222	2.880	.026	.331
Total.....	.744	9.504	.086	1.093
<i>30 doz</i>				
25 cases per pallet:				
Set up and clean up.....	.018	.216	.002	.025
Position pallet.....	.078	.960	.009	.110
Stack cases on pallet.....	.348	4.386	.040	.504
Transport to storage and return.....	.216	2.754	.025	.317
Total.....	.660	8.316	.076	.953
<i>30 doz</i>				
30 cases per pallet:				
Set up and clean up.....	.018	.216	.002	.025
Position pallet.....	.078	.960	.009	.110
Stack cases on pallet.....	.342	4.338	.039	.499
Transport to storage and return.....	.180	2.298	.021	.264
Total.....	.618	7.812	.071	.898

¹ Based on average 150-ft round trip.



PN-3955

Figure 6.—Assembling cases of eggs from storage on empty or partially loaded pallet.

Clean up consists of bracing load and closing and securing trailer doors.

- *Pick up loaded pallet, move into trailer, and set down.*

- *Return to assembly area.*

Table 6 shows the labor time and cost for loading shell eggs by electric pallet transporter using two case sizes.

Table 7 gives the total labor time and cost to unload, assemble, and load shell eggs using an electric pallet transporter and two case sizes. Costs ranged from \$0.142 per 100 dozen or \$1.81 per ton using the 30-dozen case and unloading 30 cases per pallet to \$0.174 per 100 dozen or \$2.23 per ton with the 24-dozen case and unloading 30 cases per pallet.

Table 8 shows the handling equipment costs to unload, assemble, and load at the warehouse



PN-3956

Figure 7.—Securing assembled pallet load of egg cases with cord.

TABLE 6.—Labor time and cost to load shell eggs at warehouse by electric pallet transporter using 2 case sizes ¹

Case size and labor element	Time per—		Cost per—	
	100 doz	Ton	100 doz	Ton
	<i>Man-min</i>	<i>Man-min</i>		
<i>24 doz</i>				
Set up and clean up.....	0.018	0.258	\$0.002	\$0.030
Pick up loaded pallet, move into trailer, and set down.....	.156	2.004	.018	.230
Return to storage.....	.090	1.122	.010	.129
Total.....	.264	3.384	.030	.389
<i>30 doz</i>				
Set up and clean up.....	.018	.204	.002	.023
Pick up loaded pallet, move into trailer, and set down.....	.126	1.602	.015	.184
Return to storage.....	.072	.900	.008	.104
Total.....	.216	2.706	.025	.311

¹ Based on average 150-ft round trip and 25 cases per pallet.

TABLE 7.—Labor time and cost to unload, assemble, and load shell eggs at warehouse using electric pallet transporter and 2 case sizes

Case size, operation, and cases per pallet	Time per—		Cost per—	
	100 doz	Ton	100 doz	Ton
	<i>Man-min</i>	<i>Man-min</i>		
<i>24 doz</i>				
Unload 30 cases.....	0.744	9.504	\$0.086	\$1.093
Assemble 25 cases.....	.504	6.516	.058	.749
Load 25 cases.....	.264	3.884	.080	.389
Total.....	1.512	19.404	.174	2.231
<i>30 doz</i>				
Unload 25 cases.....	.660	8.316	.076	.956
Assemble 25 cases.....	.402	5.196	.046	.598
Load 25 cases.....	.216	2.706	.025	.311
Total.....	1.278	16.218	.147	1.865
Unload 30 cases.....	.618	7.812	.071	.898
Assemble 25 cases.....	.402	5.196	.046	.598
Load 25 cases.....	.216	2.706	.025	.311
Total.....	1.236	15.714	.142	1.807

TABLE 8.—*Handling equipment costs to unload, assemble, and load shell eggs at warehouse using electric pallet transporter and 2 case sizes*¹

Case size and egg quantity	Electric pallet transporter cost	Pallet (48 by 40 in) cost	Total
24 doz per—			
100 doz ²	\$0.009	\$0.004	\$0.013
Ton ³.....	.112	.047	.159
30 doz per—			
100 doz ².....	.007	.003	.010
Ton ³.....	.094	.038	.132
100 doz ².....	.007	.003	.010
Ton ³.....	.091	.038	.129

¹ For more details, see appendix table 16.² Cost based on 30 cases per pallet at unloading.³ Cost based on 25 cases per pallet at unloading.

using an electric pallet transporter and two cases sizes. Pallet costs were based on annual ownership cost per pallet (see appendix) divided by the annual volume handled per pallet. An annual turnover rate per pallet of 130 was used for an annual volume of 3,900 cases. Costs ranged from \$0.010 per 100 dozen or \$0.129 per ton with the 30-dozen case and unloading 30 cases per pallet to \$0.013 per 100 dozen or \$0.159 per ton with the 24-dozen case and unloading 30 cases per pallet.

Another cost to consider at the warehouse is the ownership cost of the warehouse facility. Based on an assumed annual \$2 per square foot for refrigerated storage space, warehouse ownership costs amount to \$0.083 per 100 dozen or \$1.06 per ton regardless of case size.

Table 9 summarizes the total labor, handling equipment, and warehouse space costs to unload, assemble, and load shell eggs at the central warehouse using an electric pallet transporter and two case sizes. These costs ranged from \$0.235 per 100 dozen or about \$3 per ton with a 30-dozen case and unloading 30 cases per pallet to \$0.270 per 100 dozen or \$3.45 per ton with a 24-dozen case and unloading 30 cases per pallet.

From Warehouse to Retail Store.—All information in this section consists of data obtained from key personnel employed by the warehouses studied and is based on delivering shell eggs in tractor-trailers approximately 40 feet long. Two of the warehouses delivered mixed loads on their own vehicles and one delivered only eggs on vehicles it leased from a hauling company. The total volume transported in these trailers ranged from 7 to 11 tons and the round trip between warehouse and retail stores was between 45 and 70 miles. The cost of delivery for three warehouses included depreciation, interest, insurance, license, maintenance, oil, gas, and driver.

TABLE 9.—*Total labor, handling equipment, and space costs to unload, assemble, and load shell eggs at warehouse using electric pallet transporter and 2 case sizes*

Case size and egg quantity	Labor cost	Handling equipment cost	Warehouse space cost	Total
24 doz per—				
100 doz ¹	\$0.174	\$0.013	\$0.083	\$0.270
Ton ²	2.231	.159	1.060	3.450
30 doz per—				
100 doz ¹.....	.147	.010	.083	.240
Ton ²	1.865	.132	1.060	3.057
100 doz ¹.....	.142	.010	.083	.235
Ton ²	1.807	.129	1.060	2.996

¹ Cost based on 30 cases per pallet at unloading.² Cost based on 25 cases per pallet at unloading.

Based on this information, the average cost of transporting shell eggs from the central warehouse to retail stores, regardless of the case size, was \$0.90 per 100 dozen or \$11.46 per ton.

Direct-Store System Costs

Distribution within this system consisted of transporting shell eggs directly from the packing plant to retail stores.

Packing plant owners and managers reported that delivery costs to retail stores were based on the same costs as shipping to central warehouses plus a minimum of \$0.01 per dozen carton differential. Based on this \$0.01 per carton differential and using data shown in table 4 for packing plant to warehouse delivery, the cost to deliver from plant to retail outlets was \$1.71 per 100 dozen or \$21.89 per ton, as shown in the following calculation:

$$\begin{aligned} \text{Let } D &= \text{cost per 100 doz} \\ A &= \text{cost differential per dozen } (\$0.01) \\ B &= \text{cost per 100 doz to ship from plant to warehouse } (\$0.71) \\ \text{Then } D &= 100 A + B = \$1.00 + \$0.71 = \$1.71 \end{aligned}$$

$$\begin{aligned} \text{Let } T &= \text{cost per ton} \\ B &= \text{weight of 100-doz eggs (156.25 lb)} \\ M &= 1 \text{ ton} \\ D &= \text{cost per 100-doz eggs } (\$1.71) \end{aligned}$$

$$\text{Then } T = \left(\frac{B}{M} \right) (D) = \left(\frac{2,000}{156.25} \right) (\$1.71) = \$21.89$$

Total Costs

Table 10 shows the total distribution cost for each delivery system between packing plant and retail store. Distribution cost for the direct-store system amounted to \$1.71 per 100 dozen or \$21.89 per ton regardless of case size. As previously stated, trucking costs were not differentiated by case sizes. Distribution cost for the warehouse-to-store system ranged from \$1.85 per 100 dozen or \$23.53 per ton to \$1.88 per 100 dozen or \$23.98 per ton depending on case size at the warehouse.

Retail Store

The nine retail stores studied were all large supermarkets in the Washington, D.C., metropolitan area. Conditions at these stores varied from truck-bed height receiving areas to street level receiving areas; clear travel routes to

TABLE 10.—Total distribution costs between packing plant and retail store by 2 delivery systems

Case size and egg quantity	Direct-store-system cost	Warehouse-to-store system cost			Total
		Plant to warehouse	Through warehouse ¹	Warehouse to retail store	
24 doz per—					
100 doz ²	\$1.71	\$0.710	\$0.270	\$0.900	\$1.880
Ton ³	21.89	9.070	3.450	11.460	23.980
30 doz per—					
100 doz ²	1.71	.710	.240	.900	1.850
Ton ³	21.89	9.070	3.057	11.460	23.587
100 doz ² .....		.710	.235	.900	1.845
Ton ³		9.070	2.996	11.460	23.526

¹ Based on data in table 9.

² Cost based on 30 cases per pallet at unloading.

³ Cost based on 25 cases per pallet at unloading.

cluttered routes between dock and storage; cooler doors wide enough to accommodate pallets and transport equipment to doors too narrow to accommodate them. All these variables were studied and averaged to reflect typical store-operating conditions.

Handling methods for the direct-store delivery system differed from the warehouse-to-store system because the truck came directly from the packing plant and the eggs were not palletized in the trailer.

The retail store employees were not as proficient in using materials handling equipment as the warehouse employees because very little of their work required handling equipment and many of the stores had congested storage areas. Two retail store managers stated they were forced to use manual handling equipment because the electric equipment caused too much damage to the food products and the physical facility through careless handling by employees.

The following handling equipment was used in the retail stores (figs. 1 and 8):

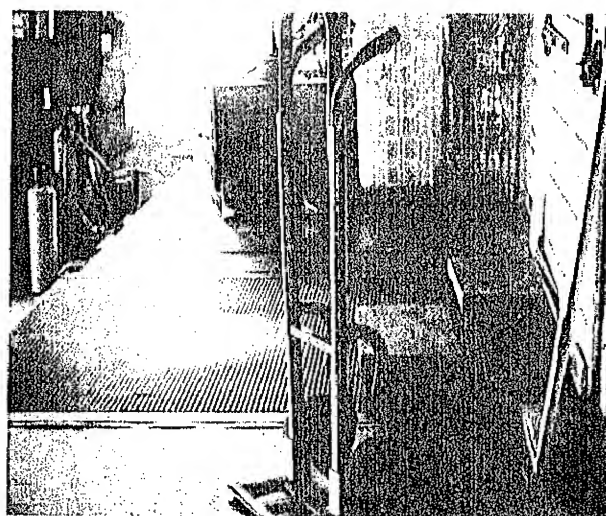
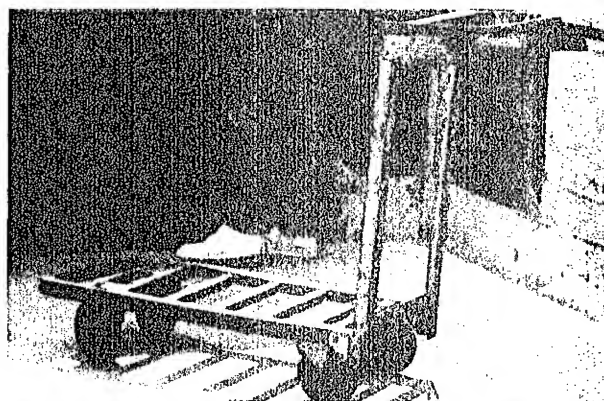
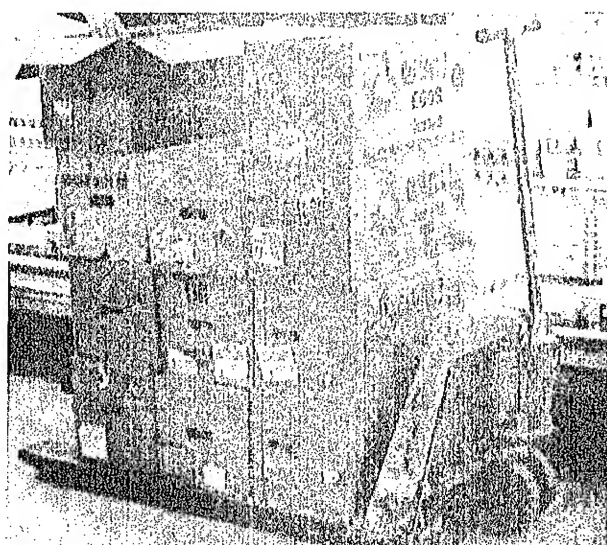
<i>Equipment</i>	<i>Capacity (pounds)</i>
Pallet transporters:	
12-V electric	2,000
Hydraulic manual	4,000
Handtrucks:	
4 wheel	2,000
2 wheel	1,000

Labor Costs

Data were obtained on labor productivity and costs from the time of the tractor-trailer arrival at the store to the storage of eggs on the display shelves. The basic labor functions were unloading shell eggs from the trailer to cooler storage and then moving them to the display counter.

Transportation distances for each function varied considerably between retail stores. Since

introducing variations in time
, all data
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Figure 8.—Handling equipment used in retail stores (top to bottom): Manual pallet transporter; 4- and 2-wheel handtrucks.

direct-line punching store receipts and at those stores without receiving docks.

The unloading function consisted of the following elements for each type of equipment:

• *Electric pallet transporter included* (1) set up and clean up and (2) pick up pallet, move to storage, and return.

• *Two-wheel handtruck included* (1) set up and clean up (2-man), (2) move cases to ground via gravity skate-wheel conveyor (2-man), and (3) move to cooler and return.

Table 11 shows the labor time and cost to unload shell eggs at the retail store and move them to cooler storage. Costs ranged from \$0.044 per 100 dozen or \$0.566 per ton with an electric pallet transporter and 30-dozen case to \$0.369 per 100 dozen or \$4.73 per ton with a two-wheel handtruck and 24-dozen case.

Handling to Display Counter.—The equipment used for this function included a manual pallet transporter and a two-wheel and a four-wheel handtruck.

TABLE 11.—*Labor time and cost to unload shell eggs at retail store and move to cooler storage using 2 case sizes and 2 types of handling equipment*¹

Case size, handling equipment, and element	Time per—		Cost per—	
	100 doz	Ton	100 doz	Ton
	<i>Man-min</i>	<i>Man-min</i>		
<i>24 doz</i>				
Electric pallet transporter: ²				
Set up and clean up.....	0.060	0.732	\$0.006	\$0.076
Pick up pallet, move to storage, and return..	.474	6.078	.049	.633
Total.....	.534	6.810	.055	.709
2-wheel handtruck:				
Set up and clean up.....	.498	6.402	.052	.667
Move cases to ground via conveyor.....	1.500	19.200	.156	2.000
Move to cooler and return.....	1.548	19.836	.161	2.066
Total.....	3.546	45.438	.369	4.733
<i>30 doz</i>				
Electric pallet transporter: ²				
Set up and clean up.....	.048	.582	.005	.061
Pick up pallet, move to storage, and return..	.378	4.848	.039	.505
Total.....	.426	5.430	.044	.566
2-wheel handtruck:				
Set up and clean up.....	.402	5.622	.042	.586
Move cases to ground via conveyor.....	1.200	16.878	.125	1.758
Move to cooler and return.....	1.236	17.436	.129	1.816
Total.....	2.838	39.936	.296	4.160

¹ Average 230-ft round trip, 25 cases per trip with electric pallet transporter, and 3.6 cases per trip with 2-wheel handtruck.

² Warehouse-to-store delivery system only.

The handling function was divided into four elements:

- *Load transporter.*—Handler picks up cases of shell eggs from cooler and places them on handling equipment. The size of the load depends on the capacity of the equipment and the demand for the eggs.

- *Transport load from cooler to display counter.*

- *Rework old cartons on display counter, open cases, mark prices, stock shelf (fig. 9).*—The first step in stocking is to rotate the old

egg cartons by either pulling them forward or setting them aside. The handler then opens egg cases and price-marks the new merchandise with an adjustable band stamp. A row of six cartons is stamped, the stamp is set aside, and the six units are placed on display. This is repeated for the remaining layers in the case. When the display counter is reasonably full, the cartons that have been set aside for rotation are placed on top.

- *Break down empty case, place on transporter, move to case disposal area, and return to cooler.*

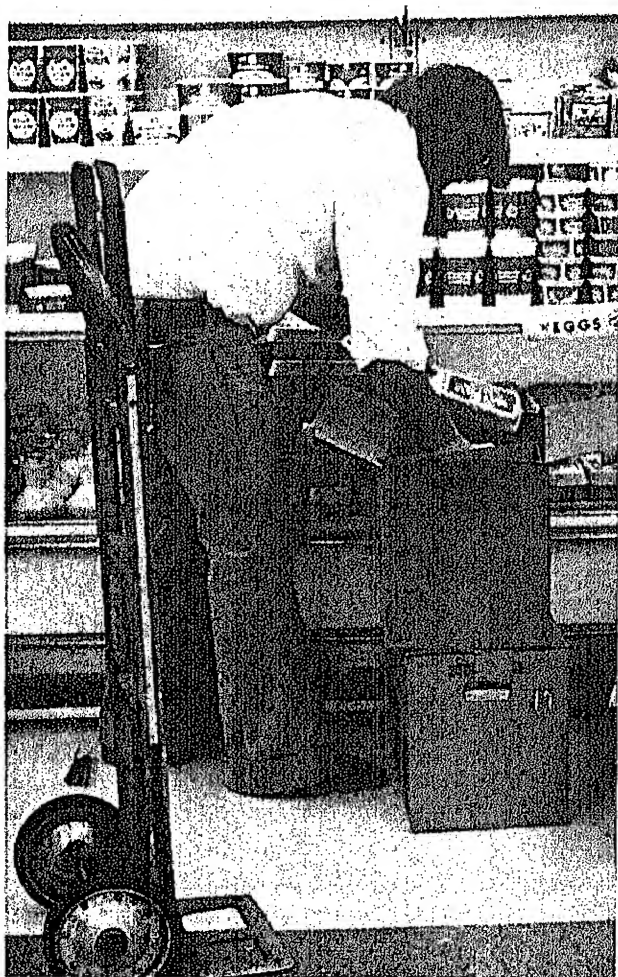
Table 12 shows the labor time and cost to handle shell eggs between cooler storage and display counter. Costs ranged from \$0.706 per 100 dozen or \$9.02 per ton with a four-wheel handtruck and a 30-dozen case to \$0.982 per 100 dozen or \$12.57 per ton with a two-wheel handtruck and a 24-dozen case.

Handling Equipment Costs

Table 13 shows the equipment costs to unload and handle shell eggs at the retail store. For the unloading operation, costs ranged from \$0.003 per ton with a two-wheel handtruck and either size case to \$0.039 per ton with an electric pallet transporter and a 24-dozen case. For handling to display counter, costs ranged from \$0.007 per ton with a two-wheel handtruck and a 30-dozen case to \$0.101 per ton with a manual pallet transporter and a 24-dozen case.

Total Costs

Table 14 shows the total labor and equipment costs to unload and handle shell eggs at the retail store using two case sizes and various types and combinations of equipment. The data are arranged to express costs for particular handling equipment combinations and not for individual pieces of equipment. Depending on the particular combination of equipment and cases, total costs ranged from \$0.75 per 100 dozen or \$9.63 per ton to \$1.35 per 100 dozen or \$17.31 per ton.



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Figure 9.—Reworking old cartons, opening cases, marking prices, and stocking shelves in retail store.

TABLE 12.—Labor time and cost to handle shell eggs at retail store between cooler storage and display counter using 2 case sizes and 3 types of equipment¹

Case size and handling element	Manual pallet transporter ²						2-wheel handtruck						4-wheel handtruck					
	Time per—		Cost per—		Time per—		Cost per—		Time per—		Cost per—		Time per—		Cost per—		Time per—	
	100 doz	Ton	100 doz	Ton	100 doz	Ton	100 doz	Ton	100 doz	Ton	100 doz	Ton	100 doz	Ton	100 doz	Ton	100 doz	Ton
	Man-min	Man-h			Man-min	Man-h			Man-min	Man-h			Man-min	Man-h			Man-min	Man-h
<i>24 doz</i>																		
Load transporter-----	0.876	0.1867	\$0.091	\$1.167	0.876	0.1867	\$0.091	\$1.167	0.876	0.1867	\$0.091	\$1.167	0.876	0.1867	\$0.091	\$1.167		
Transport load from cooler to display counter-----	.402	.0853	.042	.533	.852	.1813	.089	1.133	.402	.0853	.042	.533	.402	.0853	.042	.533		
Rework old cartons, open cases, mark prices, and stock shelf-----	6.252	1.3333	.651	8.333	6.252	1.3333	.651	8.333	6.252	1.3333	.651	8.333	6.252	1.3333	.651	8.333		
Break down empty case, place on transporter, move to case disposal area, and return to cooler-----	.378	.0800	.039	.500	1.452	.3093	.151	1.933	.324	.0693	.034	.433	.324	.0693	.034	.433		
Total-----	7.908	1.6853	.823	10.533	9.432	2.0106	.982	12.566	7.854	1.6746	.818	10.466	7.854	1.6746	.818	10.466		
<i>30 doz</i>																		
Load transporter-----	.702	.1489	.073	.930	.702	.1489	.073	.931	.702	.1489	.073	.931	.702	.1489	.073	.931		
Transport load from cooler to display counter-----	.318	.0681	.033	.426	.678	.1447	.071	.904	.318	.0681	.033	.426	.318	.0681	.033	.426		
Rework old cartons, open cases, mark prices, and stock shelf-----	5.502	1.1702	.573	7.314	5.502	1.1702	.573	7.314	5.502	1.1702	.573	7.314	5.502	1.1702	.573	7.314		
Break down empty case, place on transporter, move to case disposal area, and return to cooler-----	.300	.0638	.031	.399	1.158	.2468	.121	1.542	.258	.0553	.027	.345	.258	.0553	.027	.345		
Total-----	6.822	1.4510	.710	9.069	8.040	1.7106	.838	10.691	6.780	1.4425	.706	9.016	6.780	1.4425	.706	9.016		

¹ Average 150-ft round trip; manual pallet transporter, 2-wheel handtruck, and 4-wheel handtruck averaged 9, 3, and 12.7 cases per trip, respectively.² Pallets not used because they were inconvenient; cases stacked directly on forks.

TABLE 13.—*Equipment costs to unload and handle shell eggs at retail store using 2 case sizes and 4 types of equipment*

Handling function and equipment	24-doz case per—		30-doz case per—	
	100 doz	Ton	100 doz	Ton
Unload:				
Electric pallet transporter ¹	\$0.003	\$0.039	\$0.002	\$0.031
2-wheel handtruck.....	(²)	.003	(²)	.003
Handle to display counter:				
Manual pallet transporter.....	.008	.101	.007	.087
2-wheel handtruck.....	.001	.008	.001	.007
4-wheel handtruck.....	.001	.018	.001	.016

¹ Warehouse-to-store delivery system only.² Negligible.TABLE 14.—*Total labor and equipment costs to unload and handle shell eggs at retail store using 2 case sizes and various types and combinations of equipment*

Function and equipment		24-doz case per—		30-doz case per—	
Unloading	Handling to display counter	100 doz	Ton	100 doz	Ton
Electric pallet transporter ¹	Manual pallet transporter.....	\$0.889	\$11.382	\$0.768	\$9.753
	2-wheel handtruck.....	1.041	13.322	.885	11.295
	4-wheel handtruck.....	.877	11.282	.753	9.629
2-wheel handtruck.....	Manual pallet transporter.....	1.200	15.370	1.018	13.319
	2-wheel handtruck.....	1.852	17.810	1.185	14.861
	4-wheel handtruck.....	1.188	15.220	1.008	13.195

¹ Warehouse-to-store delivery system only.

COMPARISON OF TOTAL SYSTEMS COSTS

Total costs are compared in table 15 and figure 10 to handle and to distribute shell eggs from packing plant to retail store display counter by direct-store and warehouse-to-store delivery systems with three types of master cases for each system. The data were developed by using the most efficient handling methods found in this study for each system.

The least costly method within the direct-store delivery system was based on using a 30-dozen, 200-pound bursting strength, collapsible case. It cost \$2.99 per 100 dozen or \$38.67 per ton.

The least costly method within the warehouse-to-store delivery system was based also

on a 30-dozen, 200-pound bursting strength, collapsible case. It cost \$2.88 per 100 dozen or \$36.74 per ton.

A greater disparity of costs occurs within each of the two systems than between them, as shown in table 15 and figure 10. The difference in costs within each system amounted to \$0.62 per 100 dozen or \$7.87 per ton for the direct-store system and \$0.62 per 100 dozen or \$7.93 per ton for the warehouse-to-store system. The difference in costs between each system, using the most efficient and least costly method for each, amounted to only \$0.11 per 100 dozen or \$1.93 per ton (\$2.99 — \$2.88; \$38.67 — \$36.74).

TABLE 15.—Comparison of total costs to handle and to distribute shell eggs from packing plant to and through retail stores by direct-store and warehouse-to-store delivery systems using 3 types of master cases.

Delivery system and type of master case	Packing plant ¹	Distribution ²	Retail store ³	Total
<i>Direct-store delivery</i>				
24-doz, 275-lb bursting strength, collapsible per—				
100 doz.....	\$0.869	\$1.710	\$1.188	\$3.267
Ton.....	4.715	21.890	15.220	41.825
30-doz, 200-lb bursting strength, noncollapsible per—				
100 doz.....	.898	1.710	1.003	3.611
Ton.....	11.469	21.890	19.195	46.544
30-doz, 200-lb bursting strength, collapsible per—				
100 doz.....	.281	1.710	1.003	2.994
Ton.....	3.589	21.890	19.195	38.674
<i>Warehouse-to-store delivery</i>				
24-doz, 275-lb bursting strength, collapsible per—				
100 doz.....	.869	1.880	.877	3.126
Ton.....	4.715	23.980	11.232	39.927
30-doz, 200-lb bursting strength, noncollapsible per—				
100 doz.....	.898	1.850	.753	3.501
Ton.....	11.469	23.587	9.629	44.675
30-doz, 200-lb bursting strength, collapsible per—				
100 doz.....	.281	1.845	.753	2.879
Ton.....	3.589	23.526	9.629	36.744

¹ Based on data in table 3 for electric pallet transporter.

² Based on data in table 10.

³ Based on data in table 14. Since all eggs were assumed to be shipped unpalletized from packing plant, unloading at retail store for direct-store delivery system was based on 2-wheel handtruck, whereas unloading at retail store for warehouse-to-store system was based on electric pallet transporter because eggs were palletized at warehouse and so shipped to retail stores. Handling to display counter was based on using 4-wheel handtruck.

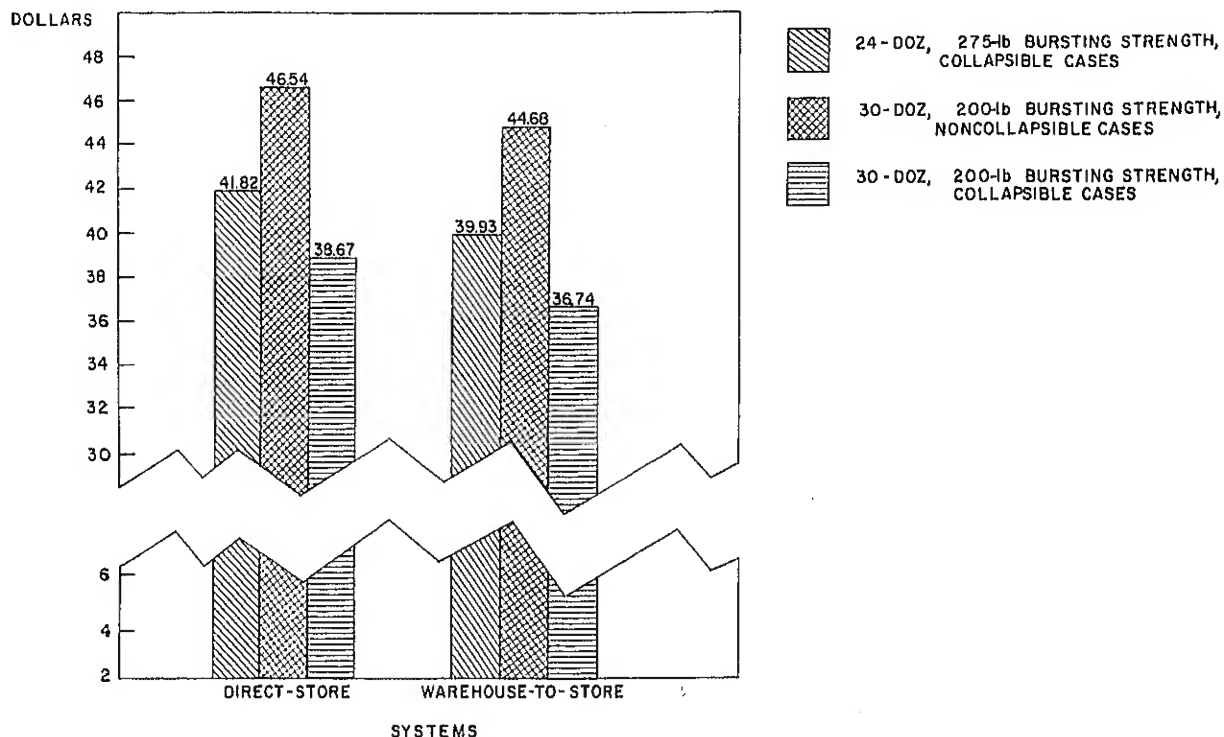


Figure 10.—Total costs per ton to handle and to distribute shell eggs for direct-store and warehouse-to-store delivery systems.

DISCUSSION

Based on the parameters in this study, the warehouse-to-store delivery system was \$0.11 per 100 dozen or \$1.93 per ton less costly than the direct-store system. These costs reflect a savings of \$29 per truckload. However, because of the constant distance factor between packing plant and retail store that has been used in this report, the stated costs should not be assumed to remain constant. They will vary with the transport distance.

The most noteworthy findings of this study indicate the potential savings the egg industry might realize by incorporating the most efficient master case into their operations. This study shows that of the three types of cases analyzed, the 30-dozen, 200-pound bursting strength, collapsible case is the most efficient and the least costly for handling and transporting shell eggs. Its use would result in a savings of up to \$7.93 per ton or \$119 per truckload.

APPENDIX

Research Techniques

Handling operations were observed and studied in detail at each of the three shell egg packing plants, three distribution warehouses, and nine retail stores. Time studies were made of these operations during the working hours and under the conditions commonly existing

in the industry. The types of handling equipment were those most often used at the various facilities along the shell egg marketing channel.

Time study techniques were used to carefully record the major elements of work performed. Each handling function, employing different combinations of handling equipment

and master cases, was studied. A decimal-minute stopwatch was used to record the time. As a worker was observed, the time required for each element of work was recorded.

Delays were recorded and identified to determine the cause. All delays classed as avoidable were removed from the time requirements established for the work. Unavoidable delays were removed from the time requirements for each operation.

While recording data for a time study, a trained observer estimated the worker's effort level, which was expressed as a percentage. The basis for comparison was a normal performance level of 100 percent. This was a measure of the effort that an experienced worker was expected to put forth in executing his assigned duties. In observing a worker, the time-study man compared the worker's effort with a normal performance. He then recorded a percent that was higher, lower, or equal to the normal rate. A higher or lower rate would indicate a higher or lower level of productivity than normal. The observed time was multiplied by the assigned percent effort level to convert it to the time that would be required if the worker studied had performed at a normal pace. The resulting time value was the base time.

The time values used in this report are productive times. The productive time is equal to the base time plus an allowance for fatigue and personal needs. The fatigue allowance is included to provide time for the assigned worker to rest to overcome the fatigue resulting from sustained physical effort. The percent value used for the fatigue allowance is directly related to physical difficulty and the working conditions associated with an assigned job. In this report a 10-percent fatigue allowance was used and 5-percent for personal needs, which was generally accepted as being adequate for worker comfort.

The total productive time in this report therefore is equal to the base time for each function plus an allowance of 10 percent for fatigue and 5 percent for personal needs.

All time values in this report are statistically valid at the 95-percent confidence limit.

Labor Costs

The hourly wage rates used in this report to derive labor costs are as follows:

<i>Facility and labor</i>	<i>Hourly rate</i>
Packing plant:	
Handlers -----	\$4.00
Truck drivers -----	5.75
Central warehouse:	
Handlers -----	6.90
Truck drivers -----	6.90
Retail store, handlers -----	6.25

These figures consist of the base hourly rates plus fringe benefits covering the cost of such items as social security, workmen's compensation, hospital and medical insurance, dental insurance, retirees' hospital and medical insurance, paid vacations, and holidays. These rates are averages of those obtained from managers and owners of the facilities studied and are considered typical.

Handling Equipment Costs

The estimated costs of owning and operating selected types of materials handling equipment analyzed in this study, based on 2,000 hours per year of use, are shown in table 16. The initial cost of equipment reflects data supplied by manufacturers and is f.o.b. at their plants. The data are current as of January 1974. The figure used for the useful life or depreciation period is in accordance with U.S. Internal Revenue Service Bulletin "F" based on reasonable life expectancy. Depreciation was calculated on a straight line basis and is equal to the initial cost of the equipment less an estimated salvage value of 10 percent divided by its useful life.

An interest rate of 9 percent was assumed to cover either the cost of borrowing money to purchase equipment or the income lost when company assets are invested in equipment.

Insurance and local taxes on the equipment vary widely from one part of this country to another. Since these items of ownership expense should be included, 4 percent was assumed to be representative of nationwide requirements.

Power costs for battery charging of electric

TABLE 16.—*Estimated costs of owning and operating selected types of materials handling equipment*

Type of equipment	Initial cost per unit	Useful life	Annual ownership cost				Annual operations cost	Total annual ownership and operations costs
			Depreciation	Interest at 9 percent	Insurance and taxes at 4 percent	Total		
Years								
Pallet transporter (4,000-lb capacity, 12-V electric walkie type).....	\$2,623.00	10.0	\$236.00	\$118.00	\$52.00	\$406.00	} \$110.20	\$691.20
Battery, 450 amp., 7.16 kWh..	536.00	6.3	77.00	24.00	11.00	112.00		
Charger.....	405.00	10.0	37.00	18.00	8.00	63.00		
Total.....	3,564.00		350.00	160.00	71.00	581.00	110.20	691.20
Pallet transporter (2,000-lb capacity, hydraulic manual).....	700.00	10.0	63.00	32.00	14.00	109.00	10.50	119.50
2-wheel handtruck (1,000-lb capacity, rubber-tired wheels).....	40.00	12.0	3.00	1.80	.80	5.60	2.20	7.80
4-wheel handtruck (2,000-lb capacity, 30 by 60 inches)...	100.00	12.0	7.50	4.50	2.00	14.00	8.80	22.80
Pallets (inches):								
48 by 40.....	7.00	5.0	1.26	.32	.14	1.72	1.75	3.47
48 by 36.....	6.25	5.0	1.12	.28	.13	1.53	1.56	3.09

¹ Includes \$57.20 for electricity and \$53.00 for maintenance.

powered vehicles were computed from manufacturers' specifications, for example—

Battery capacity = 7.16 kWh

Discharge rate per hour = 10 percent of capacity

Battery capacity per hour = $7.16 \text{ kWh} \times 0.10 = 0.716 \text{ kWh}$

Battery charging requirement per hour of vehicle use = $0.716 \text{ kWh} \times 2$ (50-percent charging efficiency) = 1.43 kWh

Charging cost per hour of vehicle use = $1.43 \text{ kWh} \times \0.02 (electricity cost per kWh) = \$0.0286

Annual power cost = $\$0.0286 \times 2,000$ (hours of annual use) = \$57.20

Maintenance costs included charges for repair and upkeep and were based on manufacturers' recommendations.

Master Case Costs

Table 17 shows the estimated case cost per trip using three types of master cases.

The initial cost was based on information supplied by box manufacturers, packing plant owners, and central distribution warehouse personnel. For the noncollapsible case, the cost of a split T liner was included. The collapsible case contained its own built-in liners.

Salvage value was estimated by salvage company and central distribution warehouse personnel.

The number of round trips per case was estimated by central distribution warehouse personnel.

The return cost of the collapsible case included the extra handling required, but it did

TABLE 17.—*Estimated case cost per trip using 3 types of master cases*

Type of case	Initial cost	Salvage value	Trips per case	Return cost	Total cost per trip per—		
					Case	100 doz	Ton
24-doz carton capacity, 275-lb bursting strength, collapsible.....	\$0.50	\$0.07	15	\$0.03	\$0.059	\$0.246	\$3.15
30-doz carton capacity, 200-lb bursting strength, noncollapsible.....	.81	.07	1	-----	.240	.800	10.21
30-doz carton capacity, 200-lb bursting strength, collapsible.....	.45	.07	15	.03	.055	.183	2.34

not include backhaul trucking charges. Trucking costs were included for the transportation function of shell eggs and were based on round trips.

The total cost per case per trip was equal to the initial cost, less the salvage value, divided by the number of times the case was used, plus the return cost.